



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: <b>PCT/GB97/03450</b> (22) International Filing Date: 12 December 1997 (12.12.97) (30) Priority Data: 9625939.5 13 December 1996 (13.12.96) GB (71) Applicant (for all designated States except US): PETROLINE WELLSYSTEMS LIMITED (GB/GB); Offshore Technol- ogy Park, Claymore Drive, Bridge of Don, Aberdeen AB23 8GD (GB). (72) Inventor; and (75) Inventor/Applicant (for US only): METCALFE, Paul, David (GB/GB); North Wing, Bucklerburn Steading, Peterculter AB14 0NP (GB). (74) Agents: McCALLUM, William, Potter et al.; Cruikshank &amp; Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
<p>(54) Title: <b>EXPANDABLE TUBING</b></p> <div data-bbox="324 1050 1169 1365"> <p>The diagram illustrates two cross-sectional views of expandable tubing. The top view shows a tubing with longitudinal slots (20) that are wider at the ends, labeled '4,000 FINGER WIDTH USING DOG BONE SLOTS'. The bottom view shows a tubing with longitudinal slots (20) that are straight, labeled '11,000 FINGER WIDTH USING STRAIGHT SLOTS'. Both views include labels 22 for the tubing wall, 24 for the slots, and 26 for the ends of the slots.</p> </div> <p>(57) Abstract</p> <p>Expandable tubing, as utilised in downhole applications in the oil and gas exploration and extraction industries, comprises tubing having a multiplicity of overlapping longitudinally extending slots (20), the slots being wider at one or both end portions. Conveniently, the slot ends are widened by the provision of short transverse slots (22), to provide the slots with a "dog bone" appearance.</p>		

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EXPANDABLE TUBING

This invention relates to expandable tubing comprising tubing have a multiplicity of overlapping longitudinally extending slots therein. In particular, but not exclusively, the invention relates to expandable tubing as  
5 utilised in downhole applications in the oil and gas exploration and extraction industries, such as the tubing sold under the EST trademark by the applicants.

WO93\25800 (Shell Internationale Research) discloses a tubing comprising lengths of tube which have been  
10 machined to create a large number of overlapping longitudinal slots. The tube may be expanded radially outwardly by running a mandrel through the tubing.

The magnitude of the force necessary to expand the tubing is related to the number of slots in the tubing,  
15 that is the fewer the number of slots the greater the expanding force. Further, expandable tubing provided with relatively few slots is more prone to fracture and catastrophic failure of the tubing during expansion. However, forming a large number of slots in a section of  
20 tubing weakens the tubing and renders the tubing more susceptible to damage during handling and running into the borehole.

It is among the objectives of embodiments of the present invention to obviate or mitigate these  
25 difficulties.

According to the present invention there is provided

expandable tubing comprising tubing having a multiplicity of overlapping longitudinally extending slots therein, at least some of the slots being wider at one or both slot end portions.

5 Surprisingly, it has been found that increasing the width of the slot ends, without increasing the width of the remainder of the slot, reduces the force required to expand the tubing without reducing the strength of the tubing to any significant degree. Without wishing to be bound by  
10 theory, it is believed that the force necessary to expand a section of tubing is a function of the width of the "finger" between adjacent overlapping slots; by enlarging the slot ends, the effective width of the finger is reduced to the circumferential spacing between the adjacent  
15 enlarged slot ends.

Preferably, each slot is wider at both ends.

Preferably also, a majority of the slots in the tubing are wider at one or both end portions.

Preferably also, the wider slot end portions are  
20 symmetrical about the respective longitudinal slot axis. Conveniently, the slot end portions are widened by provision of transverse slots at the slot ends, although other slot or recess forms, such as round holes, at or adjacent the slot ends, may be utilised. Such widening of  
25 the slot ends provides slots with a "dog bone" appearance.

As used herein, the term slot is intended to encompass any cutting, machining or weakening of the tubing intended to facilitate radial expansion, including slots which

extend only partially through the tubing and which permit the remaining thinned sections to fracture or extend.

This and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a length of prior art expandable tubing, shown in an expanded configuration;

Figure 2 is a sectional view on line 2 - 2 of Figure 1 and also shows the prior art tubing in unexpanded configuration; and

Figure 3 is a view of a portion of the wall of expandable tubing in accordance with a preferred embodiment of the present invention.

Reference is first made to Figures 1 and 2 of the drawings, which illustrate a length of conventional expandable slotted tubing 10. In its initially unexpanded configuration, the tubing 10 is simply a length of pipe in which a series of longitudinal slots 12 have been machined (shown as tube 10a with slots 12a in Figure 2). Applying radially outward force to the tubing wall, for example by passing a mandrel through the tubing, causes the tube to expand such that the slots 12a become diamond-shaped openings 12b, as described in WO93/25800.

Reference is now made to Figure 3 of the drawings, which illustrates a section of tubing wall in accordance with a preferred embodiment of the present invention. The tubing wall defines a series of longitudinal slots 20, each having shorter transverse slots 22 at the ends thereof. In

this particular example the slots 20 are 115 mm long, whereas the transverse slots 22 are 8 mm long. The area of tubing between adjacent overlapping slots is known as a finger 24, whereas the areas between the ends of aligned slots 20, which areas are generally subject to negligible deformation during expansion, are known as nodes 26.

Testing has revealed that the magnitude of force necessary to expand a section of tubing is related to the width of the fingers 24 between the overlapping slot ends. In the example illustrated in Figure 3, if the transverse slots 22 were not provided, the finger width between the slots 20 would be 11 mm. However, the provision of the transverse slots 22 reduces the effective width of the fingers 24 to only 4 mm, substantially reducing the magnitude of force which is necessary to expand the tubing. Surprisingly, it has been found that providing such transverse slots does not result in a significant decrease in the strength of the slotted tubing.

It will be clear to those of skill in the art that the above-described embodiment is merely exemplary of the present invention, and that modifications and improvements may be made thereto without departing from the scope of the invention.

CLAIMS

1. Expandable tubing comprising tubing having a multiplicity of overlapping longitudinally extending slots therein, at least some of the slots being wider at one or both slot end portions.  
5
2. The tubing of claim 1, wherein each slot is wider at both ends.
3. The tubing of claim 1 or 2, wherein a majority of the slots in the tubing are wider at least one end portion.
- 10 4. The tubing of claim 1, 2 or 3, wherein the wider slot end portions are symmetrical about the respective longitudinal slot axis.
5. The tubing of any of the preceding claims wherein the wider slot end portions include transverse slots at the  
15 slot ends.

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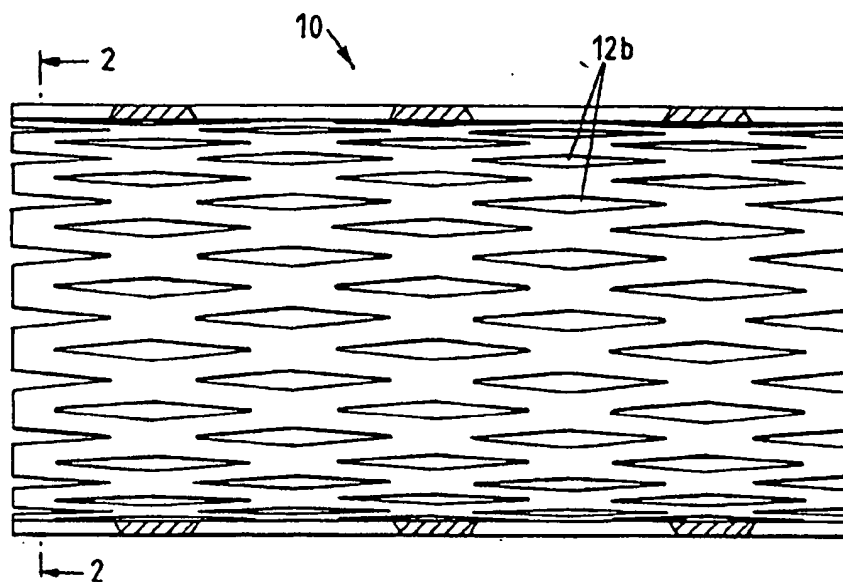


FIG. 1  
(PRIOR ART)

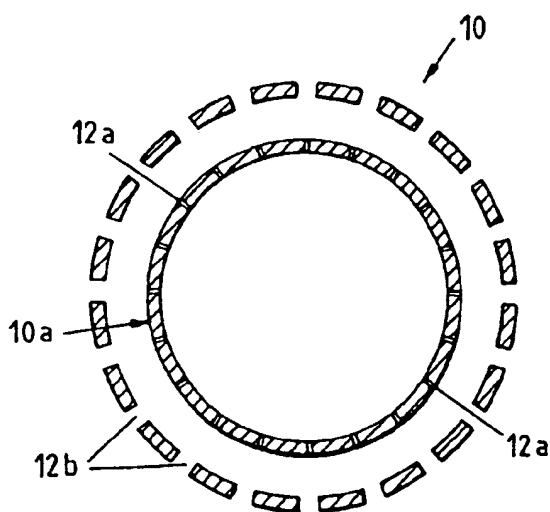
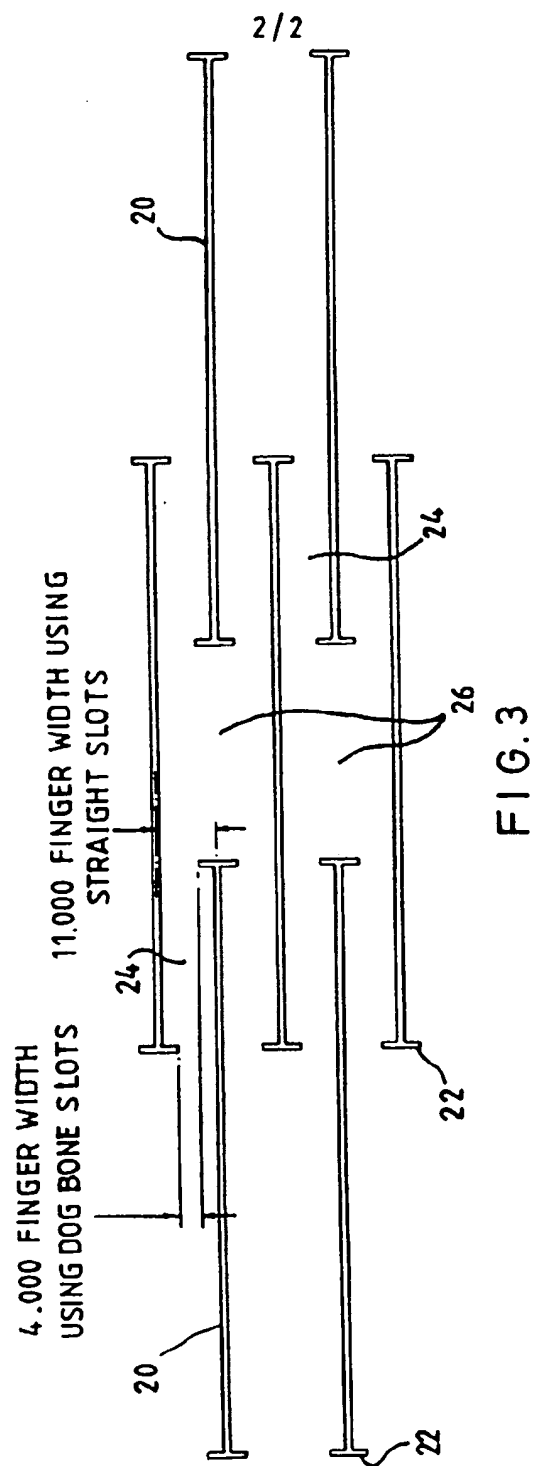


FIG. 2  
(PRIOR ART)

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SUBSTITUTE SHEET (RULE 26)

# INTERNATIONAL SEARCH REPORT

Internat'l Application No  
PCT/GB 97/03450

## A. CLASSIFICATION OF SUBJECT MATTER

E 21 B 17/08

According to International Patent Classification (IPC) or to both national classification and IPC<sup>6</sup>

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E 21 B, F 16 L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4349050 A (BERGSTROM et al.) 14 September 1982 (14.09.82), fig. 2, claims. ---	1-4
A	WO 96/37681 A1 (PETROLINE WIRELINE SERVICES LIMITED) 28 November 1996 (28.11.96), the whole document. ---	1
A	US 2633374 A (BOICE) 31 March 1953 (31.03.53), the whole document. -----	1

☐ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

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Date of the actual completion of the international search  
20 March 1998

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Name and mailing address of the ISA  
European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 SJV Rijswijk  
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# ANHANG

zum internationalen Recherchen-  
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# ANNEX

to the International Search  
Report to the International Patent  
Application No.

# ANNEXE

au rapport de recherche inter-  
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PCT/GB 97/03450 SAE 179001

In diesem Anhang sind die Mitglieder  
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This Annex lists the patent family  
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US A 4349050	14-09-82	keine - none - rien	
WO A1 9637681	28-11-96	AU A1 58265/96 AU A1 73493/96 EP A1 82462B EP A1 828918 GB A0 9510465 NO A0 975348 NO A0 975350 WO A1 9637680	11-12-96 11-12-96 25-02-98 18-03-98 19-07-95 21-11-97 21-11-97 28-11-96
US A 2633374		keine - none - rien	